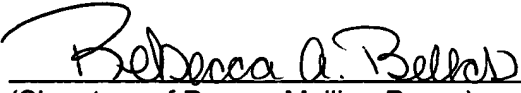


Docket No.: NANP118US
Applicant: Hirao, et al
Title: LUBRICATING BASE STOCK FOR INTERNAL
COMBUSTION ENGINE OIL AND COMPOSITION
CONTAINING THE SAME

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Rebecca A. Bellas
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(Signature of Person Mailing Paper)

SPECIFICATION

Lubricating base stock for internal combustion engine oil
and composition containing the same

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a lubricating base stock for internal combustion engine oil and a composition containing the same.

2. Description of the Related Art

In response to recent global environmental issues and the exhaustion of oil resources, there is a great demand for reduction of exhaust gas such as carbon dioxide and improvement of fuel efficiency in the automobile industry.

The improvement of fuel efficiency depends on the performance of lubricating oils. For example, it is known that when a lubricating oil having a small difference (i.e., viscosity change) between the dynamic viscosity in a low temperature state at the time of engine start and the dynamic viscosity in a high temperature state during driving is employed, that is, when a lubricating oil having a high viscosity index is employed, sufficient lubricity is maintained, and the power load on the internal combustion engine and the drive system devices is reduced, which leads to a reduction in fuel consumption.

Lubricating oils are generally made of a composition comprising a lubricating base stock as the main component to which an antioxidant or the like is added. As the lubricating base stock,

various mineral oils and synthetic oils have been developed.

As mineral oils, low viscosity index (LVI) base stocks obtained by refinery of petroleum by distillation under reduced pressure had been employed. Thereafter, high viscosity index (HVI) base stocks in which aromatic components are removed by solvent refining; high high viscosity index (HHVI) base stocks in which the oxidation stability is improved by saturating aromatic components by hydrogenation and removing other impurities as well; very high viscosity index (VHVI) base stocks in which the heat stability at high temperature is improved by hydrogenation of aromatic components under a high temperature and a high pressure; and extremely high viscosity index (XHVI) base stocks have been developed.

However, the viscosity indexes of these mineral base stocks are not sufficiently high, and the flowability and the lubricity at low temperatures are not adequate, and the improvement of fuel efficiency has not reached a satisfactory level either.

As synthetic oils, poly α -olefin (PAO), and various ester oils have been proposed. Among these, PAO is not adequate in terms of the viscosity index and the lubricity.

Japanese Laid-Open Patent Publication No. 7-305079 discloses a lubricating oil comprising a polyether polyol fatty acid ester obtained from a neopentyl polyol having 2 to 6 hydroxyl groups to which 1 to 10 moles of alkylene oxide are added and a fatty acid having 4 to 22 carbon atoms. Japanese Laid-Open Patent Publication No. 2001-139978 discloses an alkylene oxide adduct of a partial ester obtained by partial esterification of a polyhydric alcohol with a fatty acid or an ester compound obtained by partial esterification of polyethylene glycol with a fatty acid.

Furthermore, mixtures of synthetic oils and mineral oils have

been examined. For example, Japanese Laid-Open Patent Publication No. 7-228642 discloses a lubricating oil obtained by mixing a specific vinyl copolymer and a mineral oil.

All of these oils are developed to improve the lubricity and the viscosity index, but have the following problems: the pour point is high, the lubricity is poor; the viscosity index is insufficient, and the susceptibility to deterioration is high, so that the fuel efficiency is not sufficiently improved. When driving a machine or an engine, shear is applied to the lubricating oils in sliding portions of the machine or engine. Therefore, it is important to improve the viscosity (i.e., shear viscosity) characteristics of the lubricating oil in the state in which shear load is applied in order to achieve high efficiency / high fuel efficiency and maintain the lubricity at high temperature. However, in the patent publications noted above, there is no consideration on the shear viscosity characteristics of the lubricating oils.

As described above, various approaches have been followed to improve fuel efficiency, but no lubricating base stock that can improve fuel efficiency sufficiently can be obtained yet.

SUMMARY OF THE INVENTION

As a result of in-depth research to achieve the above-described objects, the inventors of the present invention found that a lubricating base stock for internal combustion engine oil comprising an ester obtained from an ethylene oxide adduct of diol having a neopentyl structure in which ethylene oxide is added to a diol having a neopentyl structure in a specific ratio and a specific saturated aliphatic monocarboxylic acid has a small change of the shear viscosity, an excellent lubricity, and high viscosity index, so that the high fuel

efficiency of automobiles can be achieved, and thus achieved the present invention.

A lubricating base stock for internal combustion engine oil of the present invention consists essentially of an ester (A) obtained from an ethylene oxide adduct of diol having a neopentyl structure and a saturated aliphatic monocarboxylic acid having 4 to 12 carbon atoms, wherein the ethylene oxide adduct is obtained by adding ethylene oxide to a diol having a neopentyl structure in a ratio of 1 to 4 moles with respect to 1 mol of the diol, wherein the saturated aliphatic monocarboxylic acid is a linear carboxylic acid or a mixture of saturated aliphatic monocarboxylic acids comprising a linear aliphatic monocarboxylic acid in a ratio of at least 50 mol%, and wherein a dynamic viscosity of the ester (A) at 100°C is 1 to 5 mm²/s, a viscosity index of the ester (A) is at least 140, and a total acid value of the ester (A) is 0.5 mg KOH/g or less.

In a preferred embodiment, the mixture of saturated aliphatic monocarboxylic acids comprises a saturated linear aliphatic monocarboxylic acid in a ratio of at least 80 mol%.

A lubricating base stock for internal combustion engine oil of the present invention consists essentially of the ester (A) and an ester (B) having an average molecular weight that is different from that of the ester (A), wherein the ester (B) is obtained from a neopentyl polyol alkylene oxide adduct and a saturated aliphatic monocarboxylic acid, and a weight ratio of the ester (A) and the ester (B) is 80 : 20 to 99.9 to 0.1.

An internal combustion engine lubricating oil composition of the present invention comprises any one of the above-mentioned base stock as a main component, 0.05 to 10 wt% of an antioxidant, 0.05 to 10 wt% of a detergent-dispersant, and 0.01 to 30 wt% of a viscosity index

improver.

Thus, the invention described herein makes possible the advantages of: providing a lubricating base stock for internal combustion engine oil consisting essentially of an ester (A) that has low viscosity, excellent flowability at low temperature and a high viscosity index and consequently has good lubricity over a wide temperature range, has a small change of shear viscosity due to temperature change, low volatility, good thermal oxidation stability, and high fuel efficiency; providing a lubricating base stock for internal combustion engine oil consisting essentially of the ester (A) and an ester (B) having an average molecular weight that is different from that of the ester (A) and having a particularly small change of the shear viscosity due to temperature change, in addition to the above-described excellent properties; and providing internal combustion engine lubricating oil composition containing the base stock.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In this specification, "lubricating base stock for internal combustion engine oil" refers to a base stock for a lubricating oil used in internal combustion engines and the associated drive systems. More specifically, it refers to a base stock for a lubricating oil used in internal combustion engines such as 2-cycle engines and 4-cycle engines; drive system devices such as manual transmissions, automatic transmissions, and power steering; and differential gears.

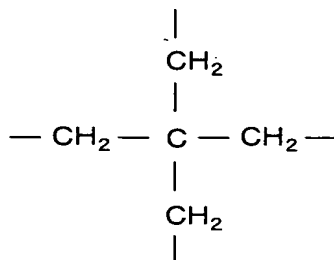
The lubricating base stock for internal combustion engine oil of the present invention consists essentially of an ester (i.e., ester (A)) obtained from an ethylene oxide adduct of diol having a neopentyl structure and a saturated aliphatic monocarboxylic acid having 4 to 12 carbon atoms, wherein the ethylene oxide adduct is obtained by adding

ethylene oxide to a diol having a neopentyl structure in a ratio of 1 to 4 moles with respect of 1 mol of the diol. Alternatively, the lubricating base stock for internal combustion engine oil of the present invention consists essentially of the ester (A) and an ester (B) having an average molecular weight that is different from that of the ester (A). The internal combustion engine lubricating oil composition of the present invention comprises the lubricating base stock as the main component. Hereinafter, the ester (A), the ester (B), the lubricating base stock for internal combustion engine oil and the internal combustion engine lubricating oil composition will be described.

(1) Ester (A)

(1.1) Ethylene oxide adduct of diol having a neopentyl structure

The ethylene oxide adduct of diol having a neopentyl structure (in the following, "ethylene oxide adduct" or the "alkylene oxide adduct" described later may be referred to simply as "adduct"), which is a raw material of the ester (A) of the base stock of the present invention, can be obtained by adding ethylene oxide to a diol having a neopentyl structure in a ratio of 1 to 4 moles with respect to 1 mol of the diol, as described above. "Diol having a neopentyl structure" refers to a diol having a neopentyl structure as shown below.



Examples of the diol having a neopentyl structure include the

following compounds: neopentyl glycol (2,2-dimethyl-1,3-propanediol), 2-ethyl-2-methyl-1,3-propanediol, 2,2-diethyl-1,3-propanediol, 2-propyl-2-methyl-1,3-propanediol, 2-propyl-2-ethyl-1,3-propanediol, 2,2-dipropyl-1,3-propanediol, 2-butyl-2-methyl-1,3-propanediol, 2-butyl-2-ethyl-1,3-propanediol, 2-butyl-2-propyl-1,3-propanediol, and 2,2-dibutyl-1,3-propanediol. By using these diols, the resultant ester can have a suitable viscosity, so that suitable lubricity can be obtained, and high fuel efficiency can be achieved. When an adduct derived from a neopentyl polyol having 3 or more hydroxyl groups is used, the resultant ester has high viscosity, so that high fuel efficiency cannot be achieved. In order to obtain an ester having a low viscosity from an adduct derived from a neopentyl polyol having 3 or more hydroxyl groups, it is necessary to employ a short chain monocarboxylic acid, and such an ester has poor lubricity.

The ethylene oxide adduct of diol having a neopentyl structure is a compound in which ethylene oxide is added to the above-mentioned diol having a neopentyl structure.

The number of moles of the ethylene oxide added is 1 to 4, preferably 1 to 3 and more preferably 1 to 2. When the number of moles of the ethylene oxide added exceeds 4, the viscosity of the resultant ester becomes high and the load torque at low temperature is increased, which may lead to deterioration of the startability at low temperature or deterioration of the thermal oxidation stability. Therefore, the lubricating oil for internal combustion engine comprising such an ester cannot withstand long term use. On the other hand, when the number of moles of the ethylene oxide added is 0, the resultant ester has problems in practical use. For example, when a short or medium chain alkyl monocarboxylic acid is used as a saturated aliphatic monocarboxylic acid as a raw material, the

resultant ester has a low viscosity index and the viscosity is too low. Therefore, when the ester is used as a base stock for lubricating oil, the oil film that is formed during driving of an internal combustion engine would be ruptured. Consequently, abrasion or seize-up may occur in the internal combustion engine using the base stock made of such an ester. When a long chain alkyl monocarboxylic acid is used, the resultant ester may be crystallized at low temperature. When alkylene oxide other than ethylene oxide, such as propylene oxide and butylene oxide, is added instead of the ethylene oxide, the resultant ester may have various problems due to the influence of its side chain alkyl. Namely, the resistance and the interaction between molecules increase at low temperature, which leads to a high viscosity. On the other hand, the molecular motion becomes active at high temperature, and the influence of the interaction of molecules is almost eliminated, which leads to a low viscosity. In other words, an ester base stock having a low viscosity index is obtained, so that improvement of fuel efficiency cannot be achieved.

(1.2) Saturated aliphatic monocarboxylic acid

The carboxylic acid that serves as a raw material of the ester (A) is a saturated aliphatic monocarboxylic acid having 4 to 12 carbon atoms, as described above. The number of carbon atoms of the saturated aliphatic monocarboxylic acid is preferably 5 to 12, more preferably 6 to 12, and even more preferably 8 to 12. When a saturated aliphatic monocarboxylic acid having 3 or less carbon atoms is employed and the resultant ester is used for a lubricating oil, the abrasion resistance effect is not adequate. On the other hand, when a saturated aliphatic monocarboxylic acid having more than 12 carbon atoms is used, the flowability at low temperature of the resultant ester

is poor. Furthermore, the viscosity is too high, which may lead to poor fuel efficiency.

As the saturated aliphatic monocarboxylic acid used in the present invention, it is necessary to include a saturated linear aliphatic monocarboxylic acid in a ratio of at least 50 mol%. Namely, the saturated aliphatic monocarboxylic acid is a linear carboxylic acid or a mixture of saturated aliphatic monocarboxylic acids comprising a linear aliphatic monocarboxylic acid in a ratio of at least 50 mol%. The saturated linear aliphatic monocarboxylic acid is contained preferably in a ratio of 80 mol% or more, more preferably 90 mol% or more, and even more preferably 95 mol% or more.

Saturated branched aliphatic monocarboxylic acids are preferable in terms of the flowability at low temperature. In particular, in terms of the hydrolysis resistance of the resultant ester, it is preferable that saturated aliphatic monocarboxylic acid having a branched chain at the carbon atom of the β position of the carboxylic acid is included. However, when the ratio of branched fatty acid is too high, the viscosity index is reduced. Therefore, the branched fatty acid is employed as appropriate in a ratio of less than 50 mol% and in the range that does not reduce the viscosity index. The ratio of the branched fatty acid is preferably less than 20 mol%, more preferably less than 10 mol%, and even more preferably less than 5 mol%.

Examples of saturated linear aliphatic monocarboxylic acids include butanoic acid, pentanoic acid, caproic acid, heptanoic acid, caprylic acid, nonanoic acid, capric acid, undecanoic acid, and lauric acid.

Examples of saturated branched aliphatic monocarboxylic acids include the following compounds: 2-methylpropanoic acid, 2-methylbutanoic acid, 3-methylbutanoic acid, 2,2-dimethylpropanoic

acid, 2-methylpentanoic acid, 3-methylpentanoic acid, 4-methylpentanoic acid, 2,2-dimethylbutanoic acid, 2-ethylbutanoic acid, 3,3-dimethylbutanoic acid, 2,2-dimethylpentanoic acid, 2-methyl-2-ethylbutanoic acid, 2,2,3-trimethylbutanoic acid, 2-ethylpentanoic acid, 3-ethylpentanoic acid, 2-methylhexanoic acid, 3-methylhexanoic acid, 4-methylhexanoic acid, 5-methylhexanoic acid, isoheptanoic acid, 2-ethylhexanoic acid, 3,5-dimethylhexanoic acid, 2,2-dimethylhexanoic acid, 2-methylheptanoic acid, 3-methylheptanoic acid, 4-methylheptanoic acid, 2-propylpentanoic acid, isooctanoic acid, 2,2-dimethylheptanoic acid, 2,2,4,4-tetramethylpentanoic acid, 3,5,5-trimethylhexanoic acid, 2-methyloctanoic acid, 2-ethylheptanoic acid, 3-methyloctanoic acid, isononanoic acid, neononanoic acid, 2,2-dimethyloctanoic acid, 2-methyl-2-ethylheptanoic acid, 2-methyl-2-propylhexanoic acid, isodecanoic acid, neodecanoic acid, and isododecanoic acid.

Other than the above, as saturated aliphatic monocarboxylic acids, derivatives of the saturated aliphatic monocarboxylic acids can be used. For example, acid chloride, methyl ester, acid anhydride or the like of these carboxylic acids can be used. Among these, it is preferable to use methyl ester or acid anhydride. Care is necessary in handling acid chloride, because a corrosive chlorine compound may be produced as a by-product when synthesizing an ester.

By using such a saturated aliphatic monocarboxylic acid, the resultant ester has excellent thermal oxidation stability. Unsaturated aliphatic carboxylic acid cannot be used in the present invention because the thermal oxidation stability of the resultant ester is poor.

(1.3) Synthesis of ester (A)

The ester (A), which is an essential component of the

lubricating base stock for internal combustion engine oil of the present invention can be obtained by reacting the above-described adduct with a saturated aliphatic monocarboxylic acid having 4 to 12 carbon atoms in any ratio. The ester can be obtained by reacting a saturated aliphatic monocarboxylic acid in a ratio of preferably about 2 to 5 moles, and more preferably about 2.1 to 4 moles, with respect to one moles of the adduct.

The ester (A) can be produced by any ordinary method. Examples of preparation of an adduct by the reaction of a diol having a neopentyl structure with ethylene oxide and preparation of an ester from the adduct will be described more specifically below. First, a diol having a neopentyl structure and a catalyst (e.g., an alkali catalyst such as alkali hydroxide, an alkali metal salt of alcohol, and an alkanolamide or an acid catalyst such as tin tetrachloride and boron trifluoride) are placed in an autoclave, and the system is purged with inert gas such as nitrogen. If necessary, moisture in the system is removed for the purpose of suppressing generation of by-products by increasing the temperature in the system to 80 to 120°C while stirring under reduced pressure. Then, after the temperature in the system is increased to 100 to 150°C, a predetermined amount of ethylene oxide is injected gradually for reaction. After the reaction is completed, if necessary, the pressure is reduced or inert gas is introduced so as to remove unreacted ethylene oxide. The alkali component contained in the obtained reaction mixture is removed with an adsorbent or neutralized with an acid, and, if necessary, the temperature in the system is kept at 80 to 120°C and under reduced pressure so as to remove moisture in the system. Furthermore, the adsorbent and a precipitated salt are removed, for example, with a filter. Thus, an ethylene oxide adduct of diol having a neopentyl structure can be

obtained. Hydroxyl groups are present at substantially all the ends of the molecule of this compound.

Then, a predetermined amount of the saturated aliphatic monocarboxylic acid is added to the adduct, and the mixture is heated to 140 to 240 °C and subjected to dehydration condensation in the absence of a catalyst or the presence of an acid catalyst such as Brensted acid or Lewis acid, if necessary, together with an azeotropic solvent. After the reaction is completed, for the purpose of removing unreacted monocarboxylic acid and reaction by-products, stripping, distillation, neutralization with alkaline water, and, if necessary, an adsorption operation using alumina, magnesia, activated clay, activated carbon, acid white clay, zeolite, ion-exchange resin or the like is performed, and purification and separation of the ester are performed by liquid chromatography or the like.

The thus obtained ester (A) has a specific dynamic viscosity, viscosity index and total acid value as shown below.

The dynamic viscosity at 100°C of the ester (A) is 1 to 5 mm²/s, preferably 2 to 5 mm²/s, and more preferably 3 to 5 mm²/s. When the dynamic viscosity of the ester is less than 1 mm²/s and drive of an engine or a machine is performed using a lubricating oil containing this ester as a base stock, the oil film thickness at a lubricating portion is reduced, which may cause rupture of the oil film and thus lead to bearing abrasion, seize-up or the like. When the dynamic viscosity is more than 5 mm²/s, the power loss due to the viscous resistance is increased, so that the startability at low temperature deteriorates and the high fuel efficiency effect cannot be obtained.

The viscosity index of the ester (A) is 140 or more, preferably 145 or more, and more preferably 150 or more.

In view of corrosion prevention, abrasion resistance and

stability, the total acid value of the ester (A) is 0.5 mg KOH/g or less, preferably 0.3 mg KOH/g or less, more preferably 0.1 mg KOH/g or less, and even more preferably 0.05 mg KOH/g or less.

The hydroxyl value of the ester (A) is preferably 5.0 mg KOH/g or less, more preferably 3.0 mg KOH/g or less, and even more preferably 1.0 mg KOH/g or less, in view of thermal oxidation stability, hygroscopicity, low volatility, and durability.

(2) Ester (B)

The ester (B) is a polyether polyol ester compound obtained from a neopentyl polyol alkylene oxide adduct and a saturated aliphatic monocarboxylic acid, wherein the adduct is obtained by adding alkylene oxide to a neopentyl polyol.

(2.1) Neopentyl polyol alkylene oxide adduct

"Neopentyl polyol" refers to a polyol having a neopentyl structure as described above.

Examples of the neopentyl polyol include a diol having a neopentyl structure described in section (1.1) (i.e., a neopentyl polyol having two hydroxyl groups), and a neopentyl polyol having 3 or more hydroxyl groups such as trimethylolpropane, pentaerythritol, and dipentaerythritol. Among these, neopentyl polyols having two hydroxyl groups, in particular, neopentyl glycol is preferable. When a neopentyl polyol having two hydroxyl groups is employed, the resultant ester can have an appropriate viscosity, so that appropriate lubricity can be obtained. When an adduct derived from a neopentyl polyol having 3 or more hydroxyl groups is employed, the viscosity of the resultant ester becomes high. In order to obtain an ester having a low viscosity, a short chain carboxylic acid has to be used. However, the lubricity of such an ester may be poor. Therefore, an adduct derived

from neopentyl polyol having 3 or more hydroxyl groups can be used as appropriate, depending on the purpose.

The neopentyl polyol alkylene oxide adduct is a compound in which alkylene oxide is added to the above-mentioned neopentyl polyol.

The number of carbon atoms of the alkylene oxide is preferable 2 to 4. Examples of alkylene oxide having 2 to 4 carbon atoms include ethylene oxide, propylene oxide, and butylene oxide. Ethylene oxide is preferable. When propylene oxide or butylene oxide is used, the resistance and the interaction between molecules are increased at low temperature because of the influence of its side chain alkyl, and therefore the viscosity is rather high. On the other hand, the molecular motion becomes active at high temperature, so that the influence of the interaction of molecules is almost eliminated, and the viscosity becomes rather low. Therefore, it is preferable to use propylene oxide adducts or butylene oxide adducts as appropriate, depending on the properties of a desired ester.

The number of moles of the alkylene oxide added is preferably 2 to 10, and more preferably 2 to 6. When the number of moles of the alkylene oxide added exceeds 10, the viscosity of the resultant ester becomes high and the load torque at low temperature is increased, which may lead to deterioration of the startability at low temperature or deterioration of the thermal oxidation stability. Therefore, a lubricating oil for internal combustion engine containing of such an ester cannot withstand long term use. When the number of moles of the alkylene oxide added is less than 2, and for example, a short or medium chain alkyl monocarboxylic acid is used as a saturated aliphatic monocarboxylic acid to be reacted, then the viscosity of the obtained ester is too low. Therefore, when driving is performed using lubricating oil containing such an ester as a base stock, the oil film

formed during driving is ruptured, and abrasion or seize-up may occur in the drive portion. When a long chain alkyl monocarboxylic acid is used, the resultant ester may be crystallized at low temperature.

(2.2) Saturated aliphatic monocarboxylic acid

There is no particular limitation regarding the number of carbon atoms of the saturated aliphatic monocarboxylic acid, but 4 to 12 are preferable and 4 to 10 are more preferable. When a saturated aliphatic monocarboxylic acid having 3 or less carbon atoms is used and a lubricating oil is prepared with the resultant ester, the abrasion resistance effect may not be adequate. On the other hand, when a saturated aliphatic monocarboxylic acid having more than 12 carbon atoms is used, the flowability at low temperature of the base stock containing the resultant ester may be poor. Furthermore, the viscosity of the resultant ester is too high, which may lead to poor fuel efficiency.

The saturated aliphatic monocarboxylic acid may be linear or branched, or a mixture of these. It is preferable that a small amount of saturated branched aliphatic monocarboxylic acid is mixed with saturated linear aliphatic monocarboxylic acid, because the flowability at low temperature of the resultant ester is excellent. In particular, in terms of the hydrolysis resistance, it is preferable that saturated aliphatic monocarboxylic acid having a branched chain at the carbon atom of the β position of the carboxylic acid is included. However, when the ratio of branched fatty acid is too high, the viscosity index of the resultant ester is reduced, and therefore branched fatty acid is used as appropriate in a range that does not reduce the viscosity index.

As the saturated linear aliphatic monocarboxylic acid and the saturated branched aliphatic monocarboxylic acid, for example, the saturated aliphatic monocarboxylic acids described in section (1.2) of

the ester (A) can be used.

(2.3) Synthesis of ester (B)

The ester (B) used in the present invention can be obtained by reacting the above-described neopentyl polyol alkylene oxide adduct with a saturated aliphatic monocarboxylic acid in any ratio. The ester can be obtained by reacting a saturated aliphatic monocarboxylic acid in a ratio of, preferably about 2 to 5 moles, and more preferably about 2.1 to 4 moles, with respect to one mol of the adduct. Such an ester (B) can be obtained by the production method described in the section of the ester (A) as above.

(3) Lubricating base stock for internal combustion engine oil

The lubricating base stock for internal combustion engine oil of the present invention consists essentially of the ester (A) obtained in the above-described manner, or consists essentially of the ester (A) and the ester (B) having an average molecular weight that is different from that of the ester (A). When the base stock consists essentially of the ester (A) and the ester (B), the weight ratio of the ester (A) and the ester (B) is 80 : 20 to 99.9 : 0.1, preferably 90 : 10 to 98 : 2. Each of the esters (A) and (B) can be a single compound or a mixture of two or more compounds. When the ratio of the esters (A) and (B) is outside the above-described ranges, it is difficult to provide sufficient temperature-shear viscosity characteristics.

When the lubricating base stock for internal combustion engine oil consists essentially of the ester (A) and the ester (B), it is preferable that the base stock has a specific dynamic viscosity (i.e., 1 to 5 mm²/s at 100°C), a specific viscosity index (i.e., 140 or more) and a specific total acid value (i.e., 0.5 mgKOH/g or less) that are in the same range as those possessed by the ester (A).

The lubricating base stock for internal combustion engine oil of the present invention, in particular, the base stock consisting essentially of the ester (A) and the ester (B) has a small change of the shear viscosity due to temperature change.

(4) Internal combustion engine lubricating oil composition

The internal combustion engine lubricating oil composition of the present invention comprises the base stock as described above as the main component, and contains (i) an antioxidant, (ii) a detergent-dispersant and (iii) an viscosity index improver. If necessary, further additives can be contained. Examples of the additives include (iv) mineral oil or non-ester synthetic oil such as poly α -olefin (PAO) and polybutene, (v) basic metal compounds, (vi) friction reducing agents, (vii) abrasion resistance agents, (viii) extreme pressure agents, (ix) rust inhibitors, (x) pour point depressants, (xi) anti-foaming agents, (xii) corrosion inhibitors, (xiii) metal deactivators, and (xiv) coloring agents.

Examples of antioxidants (i) include amine antioxidants such as alkylated diphenylamine (e.g., dioctyldiphenylamine), phenyl- α -naphthylamine, and alkylated phenyl- α -naphthylamine; phenol antioxidants such as 2,6-di-tert-butylphenol, 2,6-di-tert-butyl-4-methylphenol, 2,2'-methylenebis(4-methyl-6-tert-butylphenol), 4,4'-butylidene bis(6-t-butyl-3-methylphenol), and 4,4'-methylenebis(2,6-di-tert-butylphenol); sulfur antioxidants such as dilauryl-3,3'-thiodipropionate, and diphenyl sulfide; phosphorus antioxidants such as phosphite; dialkyl dithiophosphoric acid metal salts of zinc, molybdenum or the like. Among these, amine antioxidants, phenol antioxidants, and dialkyl dithiophosphoric acid metal salts are preferable.

The antioxidant is contained in the internal combustion

engine lubricating oil composition in a ratio of 0.05 to 10 wt%, preferably 0.1 to 5 wt%. When the content is too low, the antioxidation effect cannot be obtained. When the content is too high, it is not possible to attain an effect commensurate to the addition amount, and furthermore, sludge may be generated, and therefore too high a content is not preferable. These antioxidants can be used in combination within the above-described range of the content. The internal combustion engine lubricating oil composition of the present invention comprises an antioxidant in combination with the above-mentioned base stock having high oxidation stability, so that the oxidation stability is very good.

The detergent-dispersant (ii) may be either a metal detergent containing a metal salt or ashless dispersant that does not contain a metal salt. Examples of metal detergents include sulfonates, phenates, succinates, phosphonates, each of which contains a metal such as calcium, magnesium, barium, or sodium. Examples of ashless dispersants include copolymers of alkyl methacrylate and each of the following compounds: alkenyl succinimide compounds, alkenyl succinamide compounds, alkenyl succinate compounds, alkenyl succinate-amide compounds, benzylamine compounds, dialkylaminoethyl methacrylate, polyethylene glycol methacrylate, and vinyl pyrrolidone.

The detergent-dispersant is contained in the internal combustion engine lubricating oil composition in a ratio of 0.05 to 10 wt%, preferably 0.1 to 5 wt%. When the content is too low, sludge generated in the lubricating oil may be deposited. When the content is too high, an effect commensurate to the content cannot be obtained.

Examples of viscosity index improvers (iii) include polymethacrylate compounds, olefin copolymer compounds (e.g.,

polyisobutylene compounds, ethylene-propylene copolymer compounds), polyalkylstyrene compounds, styrene-butadiene hydrogenated copolymer compounds, styrene-maleic anhydride ester copolymer compounds, and star-shaped isoprene compounds. Among these, polymethacrylate compounds are preferable in terms of the solubility in the ester base stock. The weight average molecular weight of the polymethacrylate employed herein is particularly preferably 100000 or more (in terms of polystyrene in GPC analysis).

The viscosity index improver is contained in the internal combustion engine lubricating oil composition in a ratio of 0.01 to 30 wt%, preferably 0.1 to 20 wt%. When the content is too low, the viscosity index cannot be improved, and the fuel efficiency cannot be improved. When the content is too high, it is not possible to attain an effect commensurate to the content. Furthermore, the polymer molecules of the viscosity index improver are cut by mechanical shear, and the viscosity is reduced, so that the viscosity index may not be improved.

The various additives (iv) to (xiv) can be contained, if necessary, in order to ensure various performances as a lubricating oil in driving internal combustion engines and the associated drive systems.

The mineral oil and the non-ester synthetic oil (iv) are oil components that are added to the lubricating base stock containing the ester, and can be mixed as appropriate within the predetermined ranges of the dynamic viscosity, viscosity index, and total acid value of the lubricating base stock. Therefore, it is preferable that the mineral oil and the non-ester synthetic oil have predetermined dynamic viscosities and viscosity indexes as below.

The dynamic viscosity at 100°C of the mineral oil and the non-

ester synthetic oil is 1 to 10 mm²/s, preferably 1 to 5 mm²/s, more preferably 2 to 5 mm²/s, and even more preferably 3 to 5 mm²/s. When the dynamic viscosity is less than 1 mm²/s, the lubricating performance of the lubricating oil composition is insufficient, and the evaporation loss is large. When the dynamic viscosity is more than 10 mm²/s, the viscosity of the lubricating oil composition is increased, so that the power loss due to viscous resistance is increased, during driving of a machine or engine, and thus the fuel efficiency effect is poor.

The viscosity index of the mineral oil and the non-ester synthetic oil is preferably 90 or more, and more preferably 100 or more. When it is less than 90, the viscosity index of the lubricating oil composition is reduced, so that the fuel consumption is increased.

As the mineral oils that can be used, HVI base stocks, HHVI base stocks, VHVI base stocks, and XHVI base stocks are preferable, VHVI base stocks and XHVI base stocks are more preferable, and XHVI base stocks are even more preferable.

PAO can be obtained by polymerizing or copolymerizing one or two or more α -olefins having 2 to 16 carbon atoms, preferably 6 to 12 carbon atoms. The average polymerization degree of the PAO is preferably 2 to 10, and more preferably 2 to 7.

Specific examples of α -olefin include ethylene, propylene, butene-1, pentene-1, hexene-1, heptene-1, octene-1, nonene-1, decene-1, undecene-1, dodecene-1, tetradecene-1, and hexadecene-1. Hexene-1, heptene-1, octene-1, nonene-1, decene-1, undecene-1, and dodecene-1 are preferable.

The PAO can be produced by, for example, a method employing a Ziegler-Natta catalyst, a radical catalyst, an aluminum chloride catalyst or a catalyst comprising boron fluoride and alcohol.

The basic metal compounds (v) can be contained for the

purpose of neutralizing corrosive acid to prevent corrosion by the acid. Examples of the basic metal compounds include overbase metal compound such as sulfonate compounds and phenate compounds, each of which contains calcium, magnesium or the like. It is preferable that the basic metal compounds are contained in the composition in a ratio of 0.05 to 5 wt%.

It is considered that the friction reducing agents (vi) serve to prevent metal fusion in a sliding portion by forming a strong adsorption film on the surface of the metal of the sliding portion so as to reduce friction. For such friction reducing agents, a compound having a long chain alkyl group and a polar group in a molecule can be employed. For example, the following compounds or materials can be used: higher carboxylic acids such as oleic acid, stearic acid, and lauric acid; higher alcohols such as oleyl alcohol, stearyl alcohol, and lauryl alcohol; oil and fat such as castor oil and rape seed oil; carboxylates such as methyl oleate and butyl stearate; amine carboxylates such as tallow amine; and organic molybdenum compounds such as molybdenum dithiophosphate and molybdenum dithiocarbamate. It is preferable that the friction reducing agent is contained in the composition in a ratio of 0.05 to 3 wt%.

The abrasion resistance agents (vii) and the extreme pressure agents (viii) form a protective film on the surface of a metal on which friction is applied to reduce the abrasion of the metal and prevent seize-up. Examples of the abrasion resistance agents and the extreme pressure agents include zinc dialkyldithiophosphates; molybdenum compounds such as molybdenum dithiophosphates and molybdenum dithiocarbamates; phosphates such as tricresyl phosphate and lauryl acid phosphate; phosphites such as trioyleyl phosphite and dilauryl hydrogen phosphite; amine salts of phosphate; sulfur compounds such

as dialkyl disulfide, sulfurized oil and fat, dialkylpolysulfide, and sulfurized olefin; and chlorine compounds such as chloroparaffin and chlorinated carboxylic acid methyl esters. Among these, care is necessary for compounds containing chlorine, because they generate toxic chlorine compounds such as dioxin when being incinerated at the time of disposal. It is preferable that the abrasion resistance agents and the extreme pressure agents are contained in the composition in a ratio of 0.05 to 10 wt%. In particular, when zinc dialkyldithiophosphate is used, it is preferable that it is contained in the composition such that the zinc concentration is 0.02 to 1.2 wt%.

The rust inhibitors (ix) serve to prevent rust from occurring by adsorbing onto the surface of a metal to form a protective film or by neutralizing acids. Examples of the rust inhibitors include the following compound or materials: amines such as amine carboxylate, carboxylic acid amide, alkylimidazole, and alkylimidazoline; esters such as sorbitan monooleate, alkenylsuccinic acid half ester, and succinic acid tetrapropenyl ester; carboxylates such as oleoyl sarcosine; sulfonates such as alkali metal or alkaline earth metal salts of petroleum sulfonic acid, alkaline-earth metal salts of alkylbenzenesulfonic acid, and alkaline-earth metal salts of alkyl-naphthalenesulfonic acid; oxidized paraffin; and alkylpolyoxyethylene ether. It is preferable that the rust inhibitor is contained in the composition in a ratio of 0.01 to 3 wt%.

The pour point depressants (x) serve to prevent formation of a three-dimensional network structure by adsorbing onto the surface of crystals of a crystalline substance such as paraffin to form eutectic crystals with the crystalline substance. It is considered, as a result, aggregation is prevented, that is, the freezing point is lowered. Examples of the pour point depressant include polymethacrylate, a

condensation product of chlorinated paraffin and alkylnaphthalene, polybutene, polyalkylstyrene, and polyvinyl acetate. Polymethacrylate is preferable, and polymethacrylate having an weight average molecular weight of about 100000 is particularly preferable. Care is necessary for the condensation product of chlorinated paraffin and alkylnaphthalene, because it generates toxic chlorine compounds such as dioxin when being incinerated at the time of disposal. It is preferable that the pour point depressant is contained in the composition in a ratio of 0.01 to 5 wt%.

The anti-foaming agents (xi) can reduce the surface tension of foam films, or enter into foam films and rupture the foam films. In particular, in the case of internal combustion engines, foaming in a lubricating oil in a crankcase can be reduced. Examples of the anti-foaming agents include dimethylsiloxane and polyacrylate. The anti-foaming agent can be contained in the composition in a small amount, for example, in a ratio of about 0.002 wt%.

The lubricating base stock for internal combustion engine oil of the present invention has a low viscosity, excellent flowability at low temperature, and a high viscosity index, and thus has good lubricity over a wide range of temperatures, and has a small change of the shear viscosity due to temperature change. Furthermore, the base stock has low volatility, good thermal oxidation stability, and high fuel efficiency. The lubricating base stock for internal combustion engine oil of the present invention and the composition containing the same can be used in internal combustion engines and the associated drive systems. For example, the base stock and the composition can be used preferably in internal combustion engines such as 2-cycle engines and 4-cycle engines; drive system devices such as manual transmissions, automatic transmissions, and power steering; and differential gears.

Examples

Hereinafter, the present invention will be described more specifically by way of examples, but the present invention is not limited by the examples. In the examples, % refers to wt%.

The test method of esters produced in the examples and the comparative examples will be described below.

<Total acid value> The total acid value is measured according to JIS K2283.

<Hydroxyl value > The hydroxyl value is measured according to JIS K0070.

<Dynamic viscosity and viscosity index > The dynamic viscosity is measured with a Cannon-Fenske viscometer at 40°C and 100°C according to JIS K2283, and the viscosity index is calculated from the resultant values.

<Pour point> The pour point is measured according to JIS K2269.

<Shear viscosity > The shear viscosity is measured at 100°C and 150°C by the tapered bearing simulator method (TBS method) according to Japan petroleum Institute JPI-5S-36-91. The gap is adjusted such that the shear rate is $1 \times 10^6/\text{sec}$.

<Hot tube test > The hot tube test is performed under the following conditions according to Japan petroleum Institute JPI-5S-55-99: test temperature, 300°C; test time, 24 hours; air flow rate, 10 ± 0.5 cc/min; and test oil flow rate, 0.30 ± 0.01 cc/min.

<SRV friction abrasion test > The friction coefficient is measured under the following conditions using SRV Lubricant and Material Test System (manufactured by OPTIMOL Corporation): test temperature, 80°C; frequency, 50 Hz; amplitude, 1 mm; and loading,

500N.

Example 1

First, 1185.2 g (8.0 moles of an ethylene oxide adduct of neopentyl glycol (hereinafter, referred to as NPG-EO) (molar amount of addition: 1) as the alkylene oxide adduct of polyol having a neopentyl structure and 2764.8 g (19.2 moles) of caprylic acid as the saturated aliphatic monocarboxylic acid were placed in a four-necked flask provided with a thermometer, a nitrogen inlet tube, a stirrer, and a condenser. The mixture was allowed to react under a nitrogen stream at 220°C at an atmospheric pressure for 15 hours while water generated by the reaction was removed by distillation. After the reaction, stripping was performed under a reduced pressure of 5 kPa so as to remove excessive caprylic acid, and thus an esterified crude product was obtained.

Then, 10% potassium hydroxide corresponding to 1.5 equivalent of the acid value of the esterified crude product was added to this esterified crude product, and the mixture was stirred at 70°C for 30 minutes. Furthermore, the resultant mixture was allowed to stand for 30 minutes and the aqueous layer was removed. Then, 1000 g of ion-exchanged water was added thereto and the mixture was stirred at 70°C for 30 minutes, and thereafter was allowed to stand for 30 minutes and the aqueous layer was removed. The ester layer was washed with water four times until the pH of the discharged water became neutral, and the ester layer was dried at 100°C under a reduced pressure of 1 kPa.

To this, 30 g of Kyowaad 500 (manufactured by Kyowa Chemical Industry Co., Ltd.) was added for adsorption treatment. The adsorption temperature, the pressure and the adsorption time

were 100°C, 1 kPa, and three hours, respectively. The mixture was filtered, and thus a carboxylic acid ester of NPG-EO (molar amount of addition: 1) was obtained in an amount of 3001.2 g. The product was referred to as ester a1. The yield with respect to the initial raw materials was 76.0%.

Regarding the obtained ester a1, the dynamic viscosity, the viscosity index, the total acid value, the hydroxyl value, and the pour point were measured by the above-described method. Further, in order to examine the thermal oxidation stability, a hot tube test was performed. In this hot tube test, the higher the point is, the better the thermal oxidation stability. It is considered that the samples having at least 8 points in the hot tube test can be used in practice as the lubricating base stock or lubricating oil. Table 1 shows the results. Table 1 also shows the results of Examples 2 to 10 and Comparative Examples 1 to 7.

Examples 2 to 10

Esters a2 to a10 were produced by performing a reaction in the same manner as in Example 1, using 8.0 moles of alkylene oxide adducts of polyol having a neopentyl structure and 19.2 moles of saturated aliphatic monocarboxylic acids shown in Table 1. In Examples 5 and 9, two compounds were used as the saturated aliphatic monocarboxylic acid. The molar ratios thereof are parenthesized in Table 1. Regarding the obtained esters, the same tests as in Example 1 were performed.

Comparative Examples 1 to 7

Esters b1 to b7 were produced by performing a reaction in the same manner as in Example 1, using 8.0 moles of alkylene oxide

adducts of polyol having a neopentyl structure and 19.2 moles of saturated aliphatic monocarboxylic acids shown in Table 1. In Comparative Example 6, two compounds were used as the saturated aliphatic monocarboxylic acid. The molar ratio thereof is parenthesized in Table 1. Regarding the obtained esters, the same tests as in Example 1 were performed.

Table 1

			Examples									
Raw materials	Alkylene oxide adduct ^{a)}	Polyol having neopentyl structure	1	2	3	4	5	6	7	8	9	10
		Alkylene oxide (Molar amount of addition)	NPG	NPG	NPG	NPG	NPG	NPG	NPG	NPG	DEPG	BEPG
	Saturated aliphatic monocarboxylic acid (mol%)		EO (1)	EO (2)	EO (2)	EO (2)	EO (3)	EO (4)	EO (4)	EO (4)	EO (3)	EO (1)
			C8 (100)	C5 (100)	C10 (100)	C12 (100)	C7/bC8 (95/5)	C8 (100)	C10 (100)	C5 (100)	C7/C10 (80/20)	C9 (100)
Ester			a1	a2	a3	a4	a5	a6	a7	a8	a9	a10
Test results	Dynamic viscosity at 40°C (mm ² /s)		8.286	6.505	13.68	18.23	11.39	13.78	17.54	9.813	12.99	15.46
	Dynamic viscosity at 100°C (mm ² /s)		2.568	2.151	3.761	4.669	3.240	3.809	4.560	2.943	3.585	3.785
	Viscosity index		153	146	178	189	163	183	190	167	171	140
	Total acid value (mgKOH/g)		0.05	0.02	0.01	0.05	0.02	0.01	0.05	0.10	0.20	0.02
	Hydroxyl value (mgKOH/g)		0.5	1.6	0.7	0.1	3.6	2.1	1.3	1.1	2.4	3.4
	Pour point (°C)		<-50.0	<-50.0	-25.0	-25.0	<-50.0	<-50.0	-20.0	<-50.0	-35.0	-40.0
Hot tube test			9	9	9	9	8	8	9	8	8	8

NPG: Neopentylglycol; DEPG: 2,2-diethyl-1,3-propanediol

BEPG: 2-butyl-2-ethyl-1,3-propanediol; TMP: Trimethylolpropane

EO: Ethylene oxide; PO: propylene oxide; BO: Butylene oxide

C5: Pentanoic acid; C7: Heptanoic acid; C8: Caprylic acid; bC8: 2-Ethylhexanoic acid; C9: Nonanoic acid; C10: Capric acid; C12: lauric acid

a) Alkylene oxide adduct of polyol having neopentyl structure

Table1 (continued)

			Comparative Examples							
Raw materials	Alkylene oxide adduct ^{a)}	Polyol having neopentyl structure	1	2	3	4	5	6	7	
		Alkylene oxide (Molar amount of addition)	EO (0)	PO (3)	EO (8)	EO (3)	EO (2)	EO (3)	BO (2)	
	Saturated aliphatic monocarboxylic acid (mol%)		C10 (100)	C10 (100)	C10 (100)	C10 (100)	C10 (100)	bC8 (100)	C8/bC8 (95/5)	C9 (100)
	Ester		b1	b2	b3	b4	b5	b6	b7	
Test results	Dynamic viscosity at 40°C (mm ² /s)		25.12	20.88	24.28	14.71	11.06	26.52	15.26	
	Dynamic viscosity at 100°C (mm ² /s)		5.107	4.427	6.027	3.957	2.761	5.504	3.715	
	Viscosity index		136	124	212	179	88	124	135	
	Total acid value (mgKOH/g)		0.05	0.10	0.20	2.20	0.02	0.03	0.02	
	Hydroxyl value (mgKOH/g)		0.5	1.2	2.9	1.0	1.1	0.8	1.5	
	Pour point (°C)		-10.0	<-50.0	<-50.0	-40	<-50.0	-45.0	<-50.0	
	Hot tube test		8	7	6	5	6	7	6	

a) Alkylene oxide adduct of polyol having neopentyl structure

As can be seen from the results of Table 1, all the esters of Examples 1 to 10 have a dynamic viscosity at 100°C of about 2 to 5 mm²/s, a viscosity index of 140 or more, and a total acid value of 0.5 mg KOH/g or less. Furthermore, the values of the hot tube test were so high that no problem would be caused. These esters have low total acid values, and therefore the heat stability is excellent, and the drive portion of an internal combustion engine is not corroded or worn. The dynamic viscosity at 40°C is low and the flowability at low temperature is excellent, and the viscosity index is high, which indicates that these esters have good lubricity over a wide range of temperatures. Therefore, it is evident that these esters are useful to obtain a lubricating oil having high fuel efficiency. On the other hand, the esters of Comparative Examples 1, 2, 5, 6, and 7 have a viscosity index of less than 140, and the esters in Comparative Examples 3 and 6 have high dynamic viscosity at 100°C. Therefore, these esters cannot be used for an internal combustion engine lubricating oil having satisfactory fuel efficiency. The ester of Comparative Example 4 has a high total acid value. All the esters of Comparative Examples 2 to 7 have a low point in the hot tube test, and therefore cannot be used in practice.

Regarding the esters of Examples 2 to 4, 6 and 8, and Comparative Example 7, the shear viscosity was measured, and the shear viscosity ratio (shear viscosity at 100°C / shear viscosity at 150°C) was calculated from the obtained values of the shear viscosity. Table 2 shows the results.

Table 2

Base stock		Examples					Com. Ex.
		2	3	4	6	8	7
Shear viscosity (mPa·s)	100°C	2.01	3.26	4.03	3.46	2.82	3.22
	150°C	1.05	1.68	2.03	1.76	1.46	1.58
Shear viscosity ratio *1		1.91	1.94	1.98	1.97	1.93	2.04

*1: Ratio of shear viscosity at 100°C / shear viscosity at 150°C

The results in Table 2 indicate that the ester (ester (A)) that is an essential component of the lubricating base stock of the present invention has a small value of shear viscosity ratio (i.e., the ratio of the shear viscosity at 100°C and the shear viscosity at 150°C).

Example 11

A lubricating base stock was obtained by mixing the ester a3 of Table 1 and the ester a8 of Table 1 in a ratio shown in Table 3. The dynamic viscosity at 40°C and 100°C and the shear viscosity at 100°C and 150°C of this lubricating base stock were measured, and the shear viscosity ratio was calculated. Table 3 shows the results.

Examples 12 to 15

A lubricating base stock was obtained by mixing the ester a3 of Table 1 and the ester a8 of Table 1 in a ratio shown in Table 3. Regarding the obtained base stock, the same tests as in Example 11 were performed. Table 3 shows the results.

Comparative Example 8

A lubricating base stock was obtained by mixing the ester a3 of Table 1 and the ester a8 of Table 1 in a ratio by weight of 70 : 30. Regarding the obtained lubricating base stock, the same tests as in Example 11 were performed. Table 3 shows the results.

Examples 16 to 19 and Comparative Examples 9 to 10

A lubricating base stock was obtained by mixing the ester a3 of Table 1 and the ester b7 of Table 1 in a ratio shown in Table 4. Regarding the obtained lubricating base stock, the same tests as in Example 11 were performed. Table 4 shows the results.

Table 3

		Examples					Com.Ex
		11	12	13	14	15	8
Ester A (wt%)		a3 (98)	a3 (90)	a3 (80)	a3 (0)	a3 (100)	a3 (70)
Ester B (wt%)		a8 (2)	a8 (10)	a8 (20)	a8 (100)	a8 (0)	a8 (30)
Dynamic viscosity (mm ² /s)	40°C	13.72	13.30	12.75	9.813	13.68	12.32
	100°C	3.725	3.650	3.560	2.943	3.761	3.470
Shear viscosity (mPa·s)	100°C	3.300	3.320	3.170	2.820	3.260	3.120
	150°C	1.780	1.750	1.650	1.460	1.680	1.580
Shear viscosity ratio *1		1.85	1.90	1.92	1.93	1.94	1.97

*1: Ratio of shear viscosity at 100°C / shear viscosity at 150°C

Table 4

		Examples				Com. Examples	
		16	17	18	19	9	10
Ester A (wt%)		a3 (98)	a3 (90)	a3 (80)	a3 (100)	a3 (0)	a3 (70)
Ester B (wt%)		b7 (2)	b7 (10)	b7 (20)	b7 (0)	b7 (100)	b7 (30)
Dynamic viscosity (mm ² /s)	40°C	13.76	13.96	14.44	13.68	15.26	14.84
	100°C	3.730	3.740	3.752	3.761	3.715	3.748
Shear viscosity (mPa·s)	100°C	3.177	3.200	3.223	3.260	3.220	3.491
	150°C	1.751	1.720	1.680	1.680	1.580	1.786
Shear viscosity ratio *1		1.81	1.86	1.92	1.94	2.04	1.95

*1: Ratio of shear viscosity at 100°C / shear viscosity at 150°C

The results in Tables 3 and 4 indicate that the lubricating base stock for internal combustion engine oil containing the ester (A) and the ester (B) of the present invention in a predetermined ratio has a small value of shear viscosity ratio (i.e., the ratio of shear viscosity at 100°C and the shear viscosity at 150°C).

Example 20

A lubricating oil was prepared by mixing the ester obtained in Example 1 as the base stock, 4,4-methylenebis(2,6-di-t-butylphenol) and di(primary n-octyl) zinc dithiophosphate as antioxidants, succinimide as an ashless dispersant and polymethacrylate dispersion as the viscosity index improver in a ratio shown in Table 5. The dynamic viscosity at 40°C and 100°C, the viscosity index and the shear viscosity at 100°C of the obtained lubricating oil were measured. Furthermore, the hot tube test and the SRV friction and abrasion test were performed. Table 5 shows the results. Table 5 also shows the results of Examples 21 and 22, and Comparative Example 11.

Examples 21 and 22

Instead of the ester obtained in Example 1, the esters obtained in Examples 2 and 3 were used, and the materials shown in Table 5 were mixed in a ratio shown in Table 5 so that lubricating oils were obtained. Regarding the obtained lubricating oils, the same tests as in Example 20 were performed.

Comparative Example 11

Regarding a commercially available engine oil OW-20 (manufactured by Idemitsu Kosan Co., Ltd), the same tests as in Example 20 were performed.

Table 5

		Examples			Com. Ex.
		20	21	22	11
Materials	Base stock	a1	a2	a3	—
	Amount of base stock (wt%)	87.0	85.0	88.0	—
	4,4-Methylenebis(2,6-di- <i>t</i> -butylphenol)	0.5	0.5	0.5	—
	C8 ZDTP ^{*1} (wt%)	1.5	1.5	1.5	—
	Succinimide (wt%)	5.0	5.0	5.0	—
	Polymethacrylate (wt%)	6.0	8.0	5.0	—
	OW-20 ^{*2} (wt%)	—	—	—	100
Test results	Dynamic viscosity at 40°C (mm ² /s)	23.16	20.61	26.81	34.80
	Dynamic viscosity at 100°C (mm ² /s)	7.250	7.275	7.217	7.850
	Viscosity index	312	365	255	207
	Shear viscosity at 100°C (mPa·s)	5.00	4.84	5.22	5.46
	Hot tube test	10	10	10	10
	Friction coefficient at SRV: 500N	0.11	0.12	0.11	0.12

* 1: Di-(primary-*n*-octyl) zinc dithiophosphate

* 2: Produced by Idemitsu Kosan Co., Ltd.

As can be seen from the result of Table 5, the lubricating oils of Examples 20 to 22 have low shear viscosities, and these lubricating oils can contribute to fuel efficiency. Furthermore, these oils have excellent values in the hot tube test and have good thermal oxidation stability. On the other hand, the commercially available lubricating oil of Comparative Example 11 has a lower viscosity index and a higher shear viscosity at 100°C than those of the lubricating oils of Examples 20 to 22, and thus the fuel efficiency is lower than the lubricating oils of these examples.

The invention may be embodied in other forms without departing from the spirit or essential characteristics thereof. The embodiments disclosed in this application are to be considered in all

respects as illustrative and not limiting. The scope of the invention is indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are intended to be embraced therein.